Magnetotelluric data in the low-frequency dead band under the influence of correlated anthropogenic noise: Analysis and selection of diverse rejection criteria in robust processing

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SUMMARY

Magnetotellurics (MT) has been widely used in geophysical prospection, but it faces challenges in urbanized areas: 1) Low signal-to-noise ratio (SNR) if noise sources are close to the measurement station and/or if noise is correlated between channels and/or stations, and 2) Decreased spectral power of the natural signal due to dead-bands.

This project takes place in Annecy, France, an urbanized area in the external Alps over the Molasse Basin. The target is a karstified Jurassic marlstone-limestone with water content, a potential low-enthalpy (75ºC) shallow geothermal reservoir at 1.5-2 km depth. We aim to identify the most appropriate rejection criteria during robust processing for data affected by correlated noise and targets within the low-frequency dead band.

Data were recorded at over 40 sites across 100 km² around the active Vuache fault. Recordings lasted 1 to 12 days with sampling rates from 256 Hz to 65 kHz. A remote reference station 928 km away (Potsdam, Germany) was used for the 256 Hz band, and three local reference stations at 12, 55, and 58 km distance for higher frequency bands.

We applied the processing module of the FFMT software, which utilizes a multivariate scheme based on an eigenvalue decomposition method. The time series are segmented into frequency-oriented segments and transformed into the spectral domain. Then, a recursive multivariate regression is performed, using local site channels as observations and remote reference site channels as predictors. Thus, the spectral density matrix is calculated, and the noise covariance matrix is derived from the regression residuals. Statistical MT parameters, along with an eigenvalue-index, allow the rejection of time segments with low SNR or those contaminated with coherent noise.

Preliminary results show improvements in frequencies between 0 and 10 seconds, avoiding noise and/or typical low SNR patterns (phases decreasing close to zero and rhoa strongly increasing with period).

Keywords: Broad-band magnetotellurics, correlated anthropogenic noise, low-frequency dead band, processing criterias